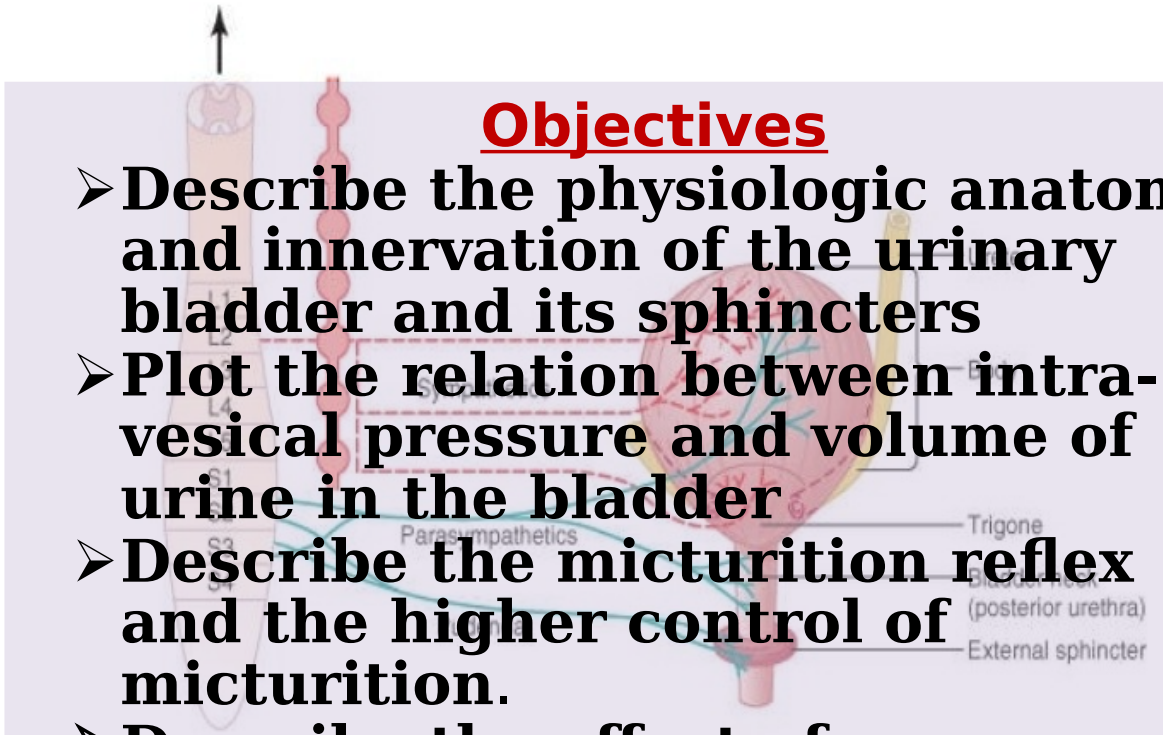
Micturition physiology Lecture



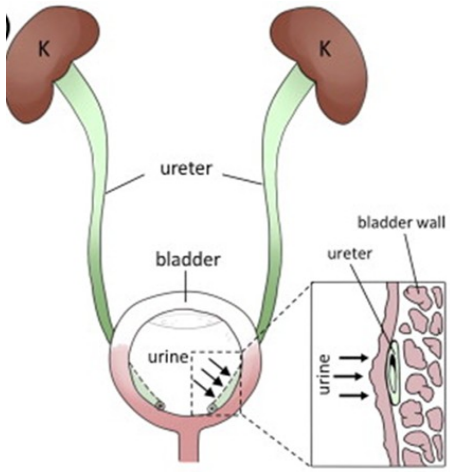
Objectives

- **Describe the physiologic anatomy and innervation of the urinary bladder and its sphincters**
- **Plot the relation between intra-vesical pressure and volume of urine in the bladder**
- **Describe the micturition reflex and the higher control of micturition.**
- **Describe the effect of neurological lesions on micturition.**
- **Select the different clinical tests for the evaluation of renal**

Micturition and assessment of renal functions

The normal urine path and bladder filling:

- Urine moves from the pelvis of the 2 kidneys to the urinary bladder through the ureter, helped by the **regular peristaltic waves (contractions)** of the smooth muscles in walls of ureter.
- **What prevents urine backflow from bladder to ureter?**
  1. The ureter penetrates the bladder wall obliquely
  2. The ureter passes through the wall before opening on the cavity, so it is compressed during voiding.



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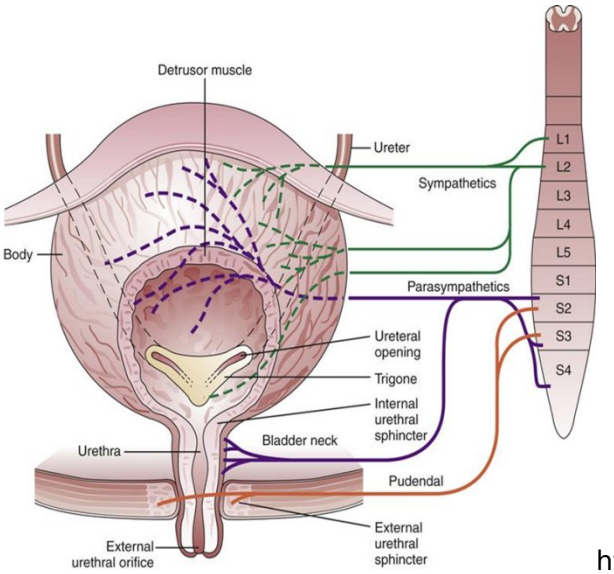
Urinary bladder has 2 functional parts:

- ❑ **Bladder Body:**

- Formed of **Detrusor muscle**:
  - Single unit smooth muscle
  - Action potential spread through gap junction, so entire bladder contract as one unit
- **Bladder neck (urethra):**
  - **Smooth muscles** on either side called **Internal urethral sphincter**
  - At the end of urethra, a sphincter of **skeletal muscles** called **External urethral sphincter**



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Bladder innervation:

1-Sympathetic efferent nerves :

- From lateral horn cells of T10-L2 , reach the bladder through hypogastric nerve
- ***Effects:***
- Relax the bladder wall by acting on Beta adrenergic receptors (β2 or β3)
- Closure of internal urethral sphincter acting on adrenergic receptors(α1)

2-Parasympathetic efferent nerves :

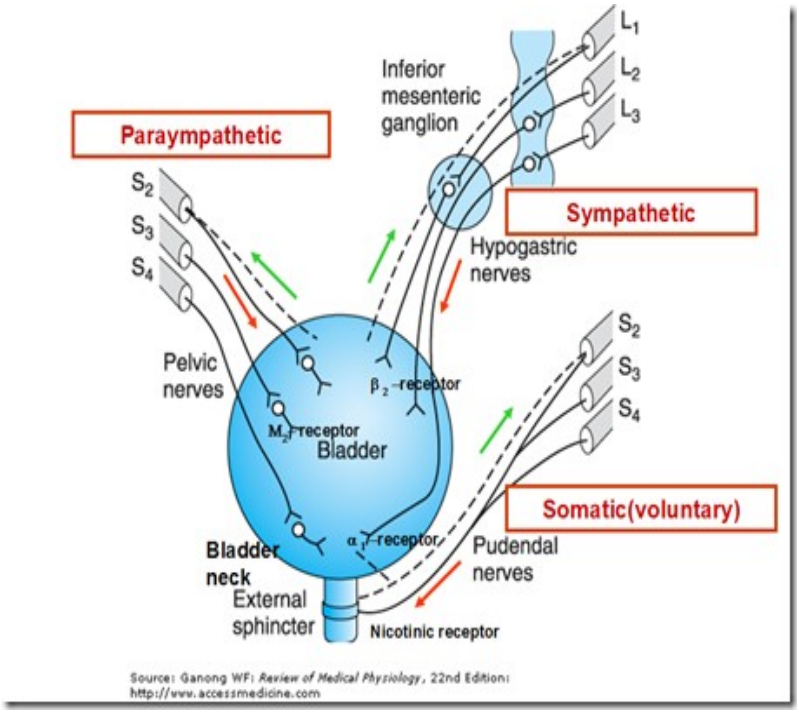
- From lateral horn cells of S2,3,4 reach the bladder through Pelvic nerve
- ***Effects:***
- Contract the bladder wall by acting on muscarinic receptors(M3)
- Mechanical opening of internal urethral sphincter

3-Somatic efferent nerves :

- From Anterior horn cells of S2,3,4 reach the bladder through **Pudendal nerve**
- ***Effects:***
- Stimulate contraction of voluntary skeletal muscle of external urethral sphincter by acetyl choline acting on nicotinic receptors.

4- Sensory afferent nerves :

- The sensory fibers carried by **pelvic nerve Parasympethetic** detect the degree of stretch in the bladder wall
- Urine flow sensation in the urethra– carried by **pudendal somatic nerve**
- Pain sensation from bladder is carried by **sympathetic fibers**



Micturition has 2 phases:

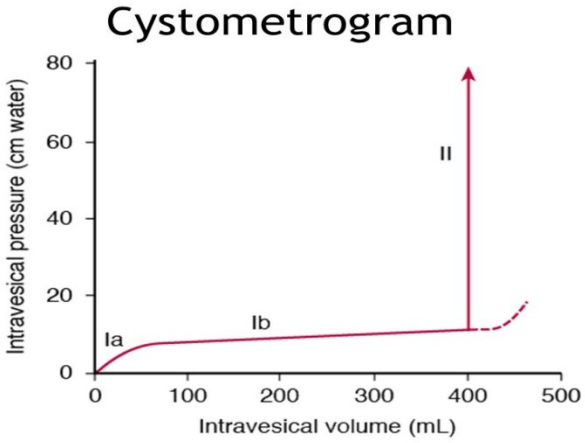
- Storage phase
- Emptying phase

:Storage phase: Bladder Filling

The bladder can accommodate large urine volumes without much increase in intra-vesical pressure (IVP.

- **Cause**
  1. The bladder muscle has the property of **plasticity**; when it is stretched, the tension initially produced is not maintained.
  2. **Laplace law**
- Less than 400 ml: both radius and tension increase and mild increase in IVP
- Above 400 ml: marked increase in tension and IVP

Relationship between intra vesical pressure -volume during bladder filling: cystometrogram



Volume	**IVP**
0	0
Ia: increase	**Mild increase**
100 ml	7-8 cm/water
Ib: 100-400 ml	10 cm/water, a **flat segment** Almost constant increase in IVP
II: At 400 ml the tension within its walls begin to rise sufficiently to activate stretch receptors	
More than 400 ml	**Sharp rise in IVP**

Bladder emptying

Bladder emptying is controlled by:

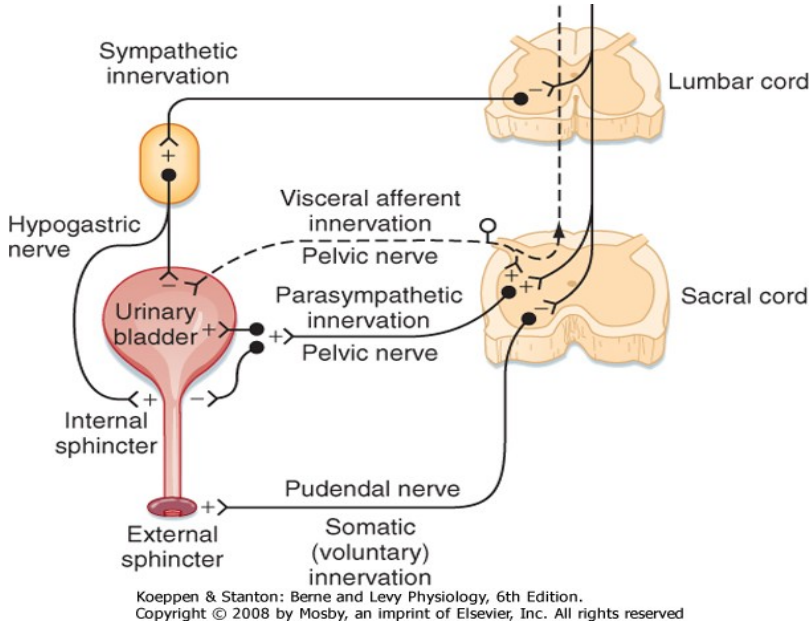
A) Micturition reflex

- The Micturition reflex is integrated in the sacral portion of the spinal cord.

- Governs emptying in infants

B) Voluntary control of micturition reflex

As the child grows up voluntary control by learning and training is achieved. Micturition reflex in adults is controlled by supra-spinal centers



A-Micturition reflex:

- **Stimulus:** Bladder distention (400 ml) and Increase in IVP--- stimulate stretch receptors in bladder wall
- **Afferent:** Bladder wall parasympathetic pelvic nerve
- **Center:** spinal cord LHC of S2,3,4
- **Efferent:**
- **A) stimulation of pelvic parasympathetic nerve on M3**
- Bladder wall contraction (M3)

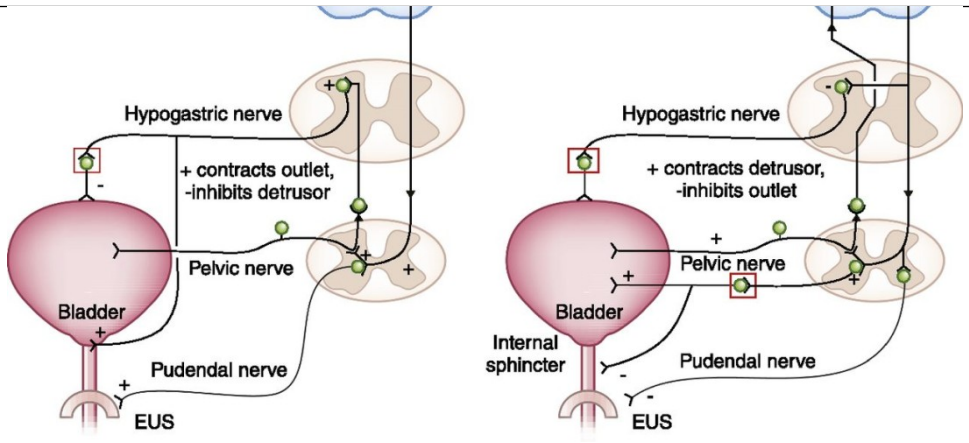
- Internal urethral sphincter opening due to changes in bladder shape during contraction mechanically pull the internal sphincter open.

- **B) Inhibition of the Pudendal somatic nerve**
- Response: Relaxation of the external urethral sphincter

B-What are the higher centers that control micturition reflex?

- Micturition reflex in adults is controlled by supra-spinal centers
- **Pons is facilitatory**
- **Midbrain, cerebral cortex is inhibitory**
- **1-** At rest there is **tonic inhibition** to prevent immediate evacuation when the volume is 400 ml.
- **2-Sensory signals:** are sent from bladder wall to higher brain centers to feel the desire of micturition when the bladder is distended through **ascending vesico-sensory tracts.**
- **3- The brain cause either facilitation or inhibition according to the situations**

• ***Suitable conditions*** ➢ **Facilitation** of sacral micturition centers: • pelvic parasympathetic nerve causes bladder wall contraction (detrusor muscle M3) , internal sphincter relaxation • Pudendal somatic nerve cause external sphincter relaxation	• **Unsuitable conditions:** ➢ **Inhibitory** cortical impulses continue → ***inhibit micturition reflex :*** • Voluntary contraction of external sphincter and pelvic diaphragm.
If urine volume exceeds 600ml → failure of voluntary inhibition leads to obligatory micturition	



- The higher centers keep the micturition reflex partially inhibited, except when micturition is desired.
- **Micturition can be initiated voluntarily :**
  - By relaxing the external sphincter and pelvic diaphragm, contracting
  - the abdominal wall and respiratory diaphragm
- **The higher centers can prevent micturition, even if the micturition reflex occurs**,:
  - By continual tonic contraction of the external bladder sphincter until a convenient time presents itself

Micturition abnormalities:

• **Atonic bladder**	• **Automatic bladder**
Loss of bladder sensation *Cause:* ▪ Interruption of sacral dorsal nerve roots as in tabes dorsalis ▪ Destruction of sensory nerve fiber from urinary bladder to	Loss of voluntary contraction • *Cause:* Disconnection of sacral micturition center from brain due to spinal cord transection above sacral region: stage of recovery of

spinal cord ▪ Shock stage of complete spinal cord transection Loss of micturition reflex **Retention with overflow**	reflexes **Reflex bladder evacuation**

Renal function tests:

1- Clearance Tests:

- **Assessment of Glomerular Filtration Rate (GFR)**

A) **Inulin clearance:**

- Disadvantages: inulin is not a normal constituent of the body and has to be injected

B) Creatinine clearance:

- More commonly used
- Advantages: easy and reliable method.

- **Assessment of Renal plasma flow (RPF)**

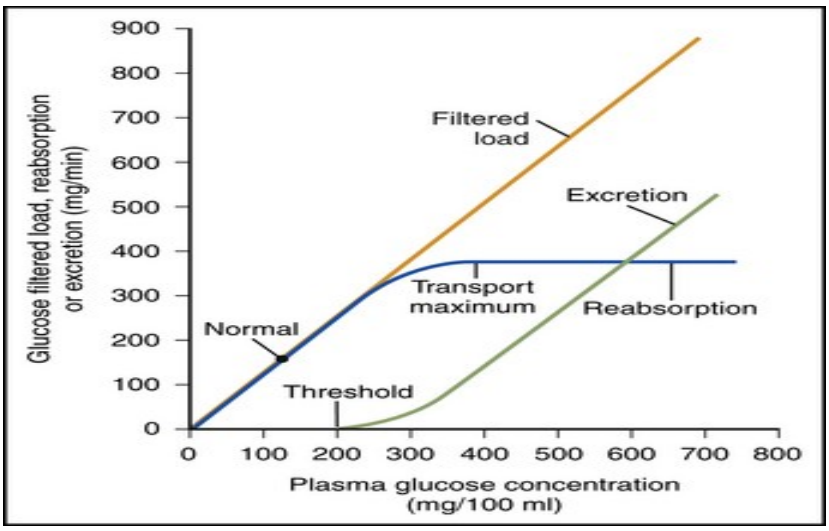
By calculating clearance of PAH

Disadvantages: cannot be used to measure Renal Blood flow in compromised patients.

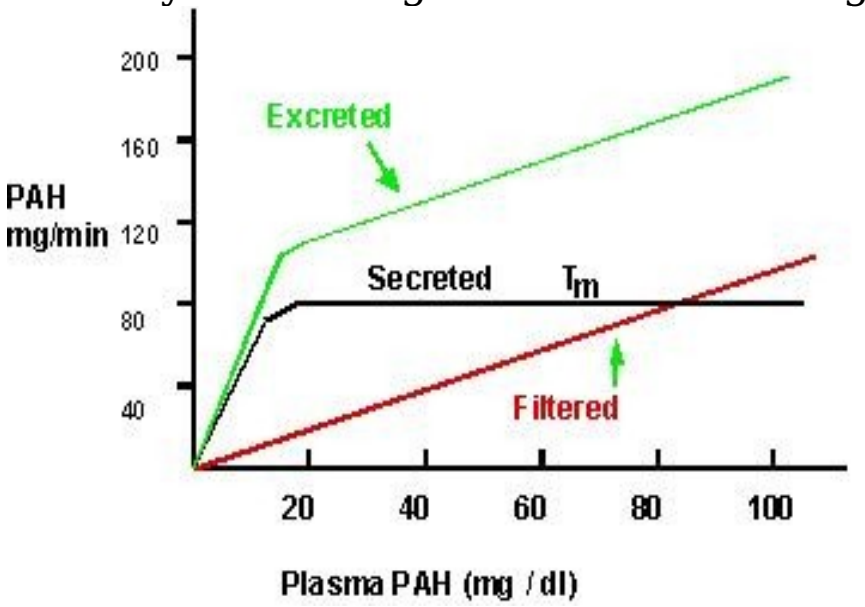
Instead, radioactive isotope can be used

2- Tubular functions : Transport maximum test

A-Assessment of renal tubular absorptive power by measuring Tm of glucose = 375 mg/min



- B- Assessment of renal tubular secretory power by measuring Tm of PAH = 80 mg/min



3- Blood tests:

- Blood urea nitrogen (BUN): 8–25 mg/dl {affected by protein intake}
- Creatinine (Cr): 0.8–1.2 mg/dl
- Serum potassium: 3.5- 5 meq/L
- Serum phosphate: 2.5-4.5 mg/dl
- Serum bicarbonate: 25-30 meq/L

4- urine analysis:

- Color: yellow amber
- Urine PH: acidic
- Urine volume: average (800ml-2000 ml/day) according to water intake
- Urine specific gravity: 1003- 1030
- Urine osmolarity: 80 – 1200 mosm/L
- Test for albuminuria, glucosuria and hematuria

5- Water dilution test:

The subject evacuates his bladder and then drinks 1.5 liters of water.

2- Urine is collected from the bladder every one hour for 5 hours.

3- Urine volume should be not less than 800 ml, osmolarity around 80 m osm and specific gravity around 1003 (below 1010).

6-Water concentration test:

1-The subject evacuates his bladder and is then prevented from taking fluids for 10-12 hours to produce dehydration.

2- At the end of 12 hours a urine sample is taken and the specific gravity is measured.

3- Small volume of concentrated urine, specific gravity more than 1025

Note: severe renal damage specific gravity is fixed at 1010

Imaging studies:

- Plain x ray to detect opaque stones
- Renal ultrasonography, because it is safe, easy to do
- Intravenous pyelography

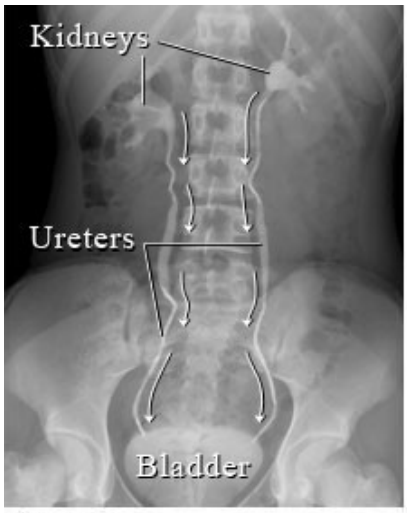


Figure 1

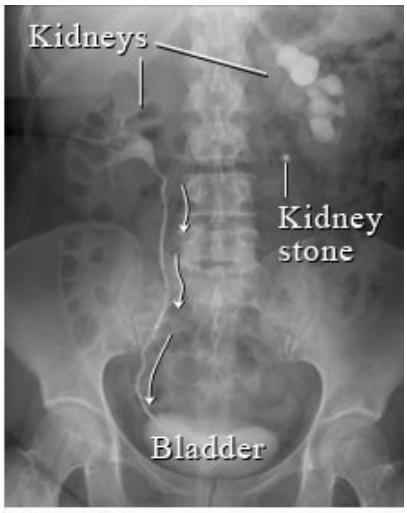


Figure 2